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Case Report

Three-dimensional reconstitution of bullet trajectory in gunshot wounds: A case report

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ABSTRACT

In the medico-legal assessment of cases of aggression with firearms, imaging techniques have a particularly important role, especially in the study of a bullet's path through the victim's body. The analysis of these trajectories can be performed by the use of three-dimensional reconstitution techniques, namely *Three-Dimensional Multi-Slice Computed Tomography* (3D-MSCT). This imaging technique has been widely used in fatal cases, as a very important complement of the classical autopsy procedures, becoming known as "virtual autopsy" or "Virtopsy". To our knowledge, no reports describing the use of 3D-MSCT in non-fatal cases have been described in the medico-legal literature. The authors present a case of a man with a gunshot injury, in the context of a multiple aggressor situation, in which it was not possible to extract the bullet. To accurately determine the bullet's trajectory, 3D-MSCT was performed, thus contributing to a more reliable reconstruction of the crime scene in which the victim and the suspects were located.

1. Introduction

Forensic radiology methods and specifically modern cross-sectional imaging techniques are being increasingly used in the routine practice of forensic pathology and their importance in forensic medicine is widely recognized.[1–7] Quite the opposite can be said in the assessment of non-fatal cases, namely in the forensic clinical medicine routine practice.[8] Imaging methods applied to forensic pathology allow accurate location of bullets and their fragments in the body, establishing its path through it, and also allow an estimate of the type and calibre of the ammunition, among other important features.[4–6] For localizing bullets, classical X-rays were used soon after their discovery by Conrad Röntgen in 1895.[9] In forensic pathology the recovery of these foreign objects is both possible and essential, but this is not necessarily so in non-fatal cases. The retrieval of the ammunition is always desirable as it may exhibit unique features/marks that help identify the particular weapon used in a specific situation.[4,10] In cases of subjects that survive their gunshot injuries, recovery of the bullet is not always possible, as the location and potential risks incurred in the surgical extraction have to be taken into account. The identification of the bullet's path through the body is one of the most important questions to be solved in any case of gunshot injury, fatal or non-fatal.[4] In those cases in which the retrieval of the bullet in a surviving individual is impossible, this knowledge becomes of the highest relevance when reconstructing the crime scene and determining the position of the victim and aggressor, even more in situations of multiple perpetrators.

2. Case report

In May 2007, a 21 year-old man was examined in the Forensic Clinical Medicine Department of the North Branch of the National Institute of Legal Medicine, in the sequence of an aggression with a firearm.

The crime scene was a crowded disco club, were the victim was with a large group of friends. Late in the night, and after having ingested a significant amount of alcoholic drinks, he got involved in a dispute with a group of individuals. At some point the victim described that a gunshot was heard, but everything was blurred in his head, so he couldn't notice who had the firearm and who shot him.

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Victim was observed and given proper medical attention immediately after being shot. The information on the clinical file of the hospital described a perforating wound of the lateral face of the left leg. Conventional X-rays of the left leg were obtained and revealed a bullet trajectory in the tibiae with incomplete fracture of the bone and a unique metallic fragment in the gastrocnemius muscle area. The attending orthopaedic surgeons decided that no surgical treatment was indicated, and prescribed conservative treatment of the fracture.

In the medico-legal physical examination performed 6.5 months after the aggression, no more than a rounded scar with an area of 1 cm^2 was visible on the upper third of the lateral face of the left leg. As there was no exit wound, this data was not sufficient for the proper establishment of the bullet's path. Conventional X-rays performed during the following healing months (antero-posterior, oblique and lateral incidences of the left leg) were also not accurate enough in the determination of the trajectory, as the healing process of the living bone tissue began to mask the entrance point and to create some artefacts along the path.

By that time, the police investigation came up with a few suspects, but there was no bullet for comparison with the alleged firearm, and only the witnesses present at that night could eventually help to reconstitute the crime scene. Thus, there was an increased need to determine as accurately as possible, the exact path of the bullet in the victim's body.

MSCT scanning of the leg was performed on a 64-slice CT scanner (Somaton Sensation Cardiac, SiemensMedical Solutions, Forchheim, Germany) with 0.75 mm collimation. No oral or intravenous contrast was administered. The images were reconstructed at 0.5 mm intervals and the total examination time was 4.5 s. The axial thin images were then loaded into a Leonardo workstation equipped with Syngo CT software (Siemens Medical Solutions, Forchheim, Germany), and two and three-dimensional reconstructions were performed using different algorithms.

The 3D-MSCT performed revealed a trajectory up-to-down, left-to-right and anterior–posterior in the upper third of the tibiae (Figs. 1 and 2). It also demonstrated the presence of two metallic density fragments of the bullet, one of them still located in the medullar canal of the tibiae and the other one in the gastrocnemius muscle area (Figs. 1 and 2). The entrance point and the skin lesion were also clearly identified in the soft tissue 3D reconstruction (Fig. 3).

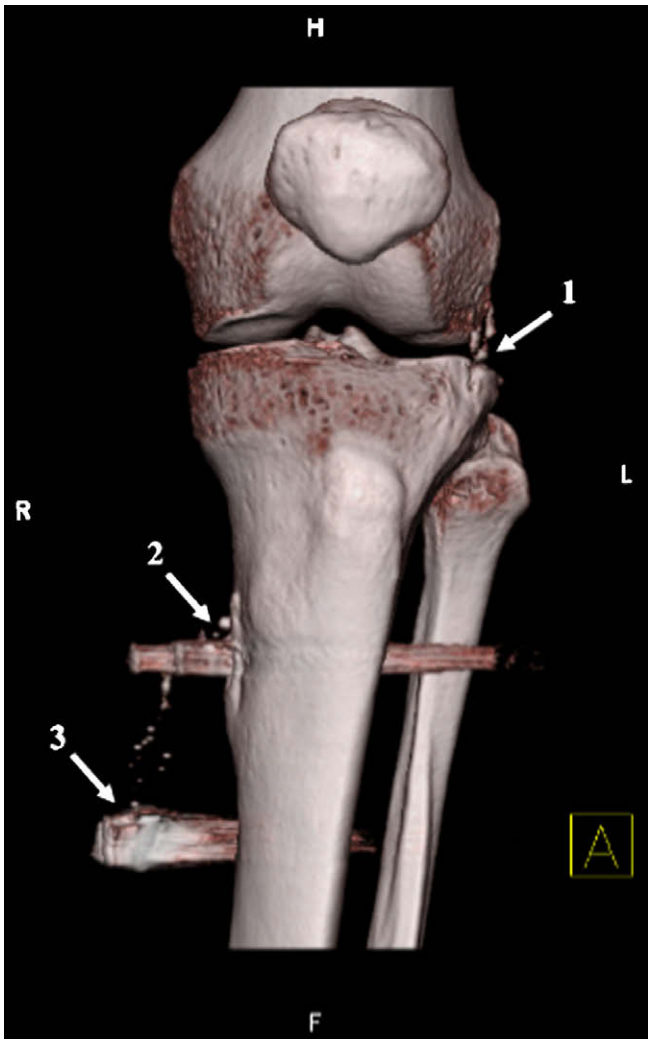

Fig. 1. 3D-volume rendered image (anterior aspect: A) revealing the projectile entrance point (1) and exit point (2) along with small bone fragments. It can also be identified one bullet fragment in the soft tissue area (3), along with the typical linear artefact.

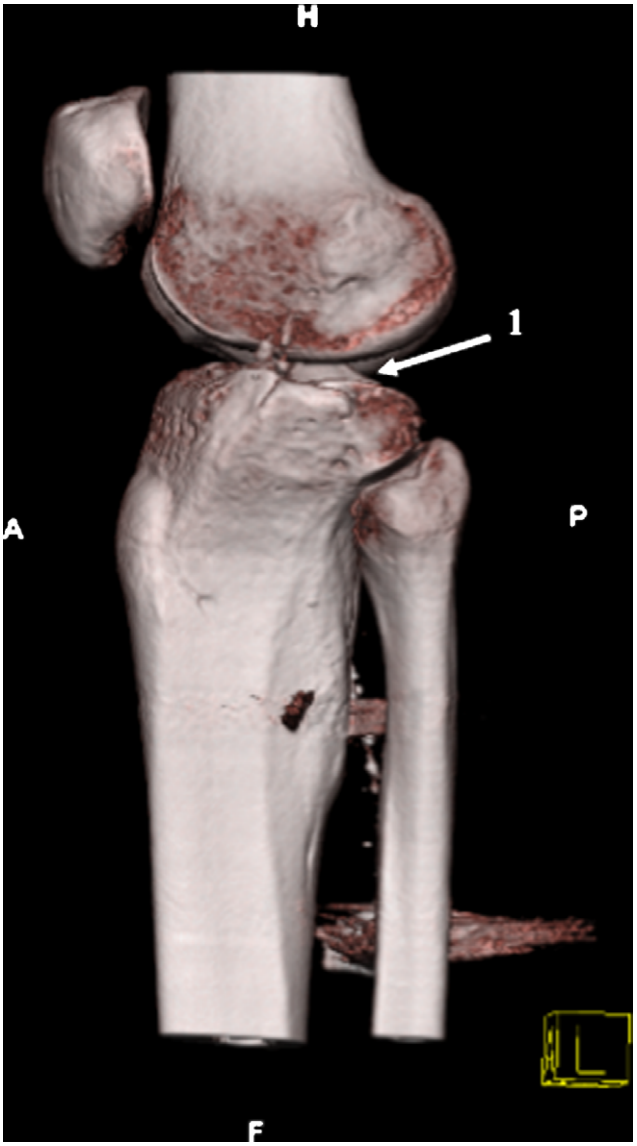

Fig. 2. 3D-volume rendered image (left aspect: L) revealing the projectile entrance point (1) along with small bone fragments. The typical linear artefact is caused by the presence of the metallic particles.

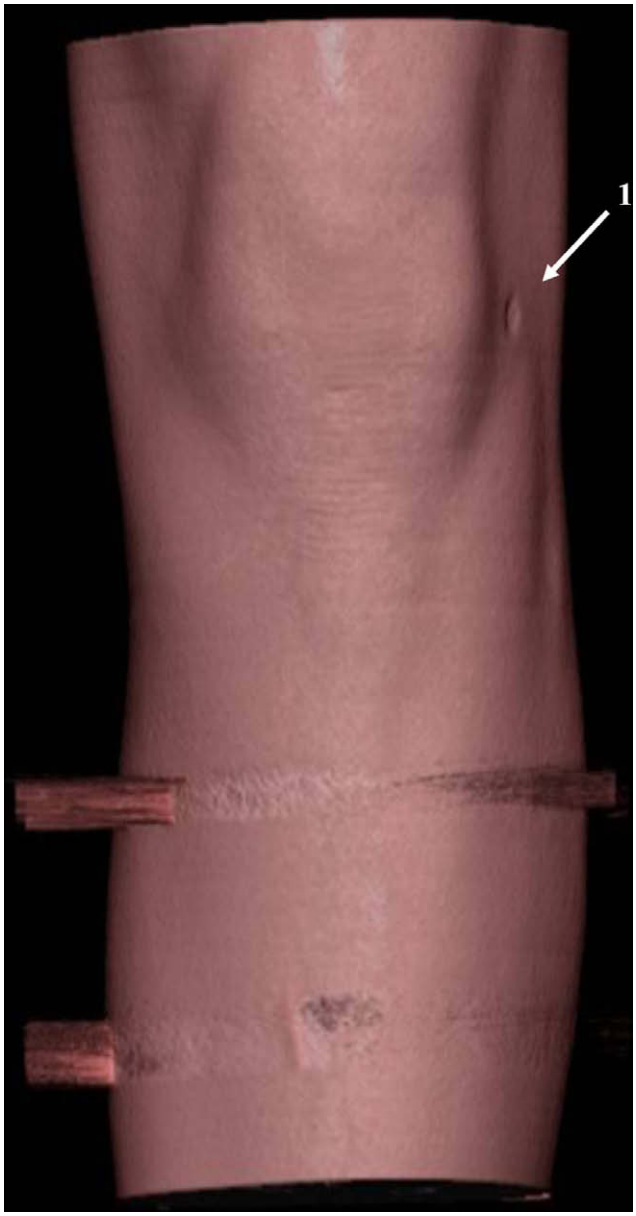

Fig. 3. 3D-volume rendered image from the anterior aspect of the knee, with skin filter, revealing the scar at the entrance point (1) and the linear artefacts induced by the presence of metallic fragments.

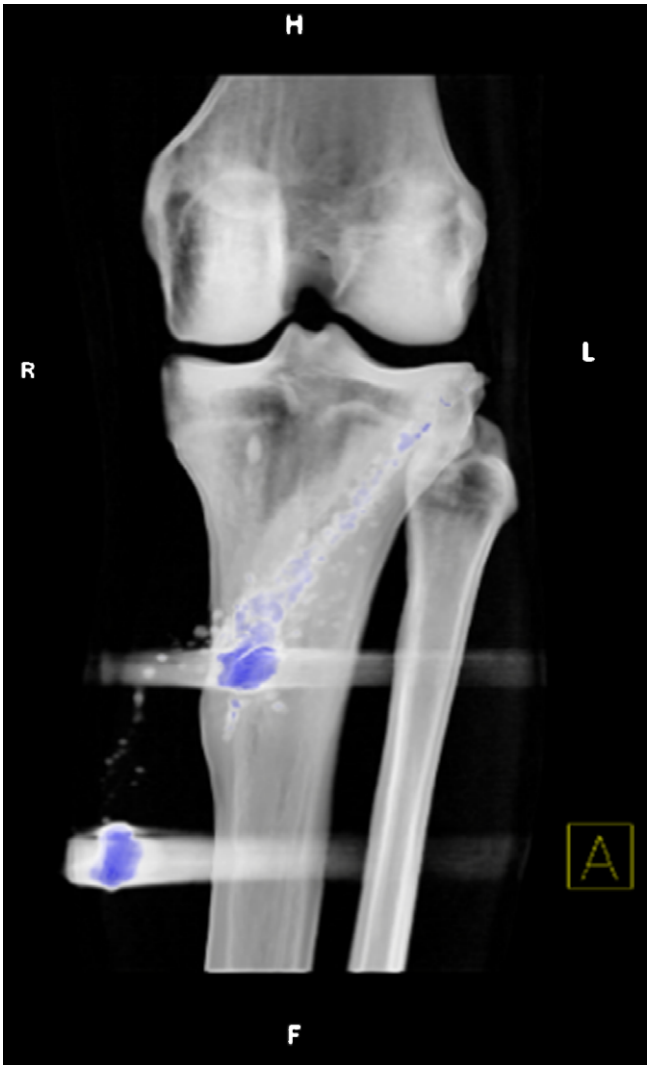

Fig. 4. 3D-volume rendered image with special filter for metallic density material demonstrating the two fragments of the projectile and the multiple thin metallic particles trail along the trajectory, coded in blue.

3. Discussion

Conventional X-ray examinations when used to assess bullet fragments location and their trajectory in the victim's body have a very well known and important limitation: transforming a three dimensional body area into a two dimensional image.[4,8] Although the utilization of two orthogonal projections can aid in the determination of the fragment's location, they may be difficult to perform in some patients.

Conventional CT has the advantage of being able to accurately depict the location of the fragments, but only in the axial plane. These axial images can be reformatted in other planes but the resolution is not always adequate and the final result is often unsatisfactory.[8]

The recent introduction of multislice CT scanners has enabled the acquisition of truly isotropic data sets with submillimetre resolution. One of the major benefits of this technique is the possibility to reconstruct the data set obtained in any plane desired, as well as to perform truly 3D reconstructions and to obtain volume rendered images using different algorithm reconstructions. The soft tissue algorithm used in this case clearly demonstrated the cutaneous lesion present at the time of the examination (Fig. 3) while the metallic algorithm reconstruction was particularly useful in the depiction of the location of the metallic fragments as well as the millimetric metallic particles along the bullet's path (Fig. 4).

The result of the three-dimensional study performed in this case is currently held by the police authority in charge of the investigation. The outcome of this investigation is still unknown to the authors since the case is still open. Nevertheless, feedback given by the police authority revealed that the three-dimensional reconstitution performed in this situation was of great importance in the reconstruction of the crime scene.

4. Conclusions

In the present case, examination with 3D-MSCT yielded superior and more reliable results with respect to the documentation and reconstitution of the inflicted gunshot wound. These results were possible due to the specific characteristics of this technique,

which allow multi-planar reconstructions in any orientation or plane. This enabled a correct evaluation of the bullet's skin entrance point, its path in and after its exit of the bone, as well as establishing its relation with the enveloping soft tissues. The correct location of the two metallic fragments present in the soft tissues was also possible to establish. This case highlights the importance and possible role of 3D-MSCT in the criminal investigation of cases of multiple suspects in which an accurate determination of a bullet's trajectory is required.

Conflict of Interest

We confirm that the material presented in this manuscript is original and has been submitted solely to this journal, and has been prepared in accordance with the instructions given.

We, also, confirm that all authors have seen and approved the submitted version of the manuscript and had full access to all of the data in this study.

We confirm that all research has been carried out in accordance with legal requirements of the study field.

Finally, we also state that neither the author nor any of the co-author has any potential conflict of interests related to the publication of this paper.

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Ethical Approval

This study has been carried out in accordance with ethical rules and it has not been submitted to Ethical Approval because it is a case report in which no invasive studies were carried out nor identification of the individual was given.

References

1. Kennedy F, Sullivan J, Arellano D, Roulier R. Evaluating the role of physical and radiographic examinations in assessing bullet tract termination for gunshot victims. *Am Surgeon* 2000;**66**:296–301.
2. Aghayev E, Staub L, Dirnhofer R, et al. Virtopsy – the concept of a centralized database in forensic medicine for analysis and comparison of radiological and autopsy data. *J Forensic Leg Med* 2008;**15**:135–40.
3. Verhoff MA, Ramsthaler F, Krähahn J, et al. Digital Forensic osteology – possibilities in cooperation with the Virtopsy® project. *Forensic Sci Int* 2008;**174**:152–6.
4. Andenmatten MA, Thali MJ, Kneubuehl BP, et al. Gunshot injuries detected by post-mortem multislice computed tomography (MSCT): a feasibility study. *Legal Med*. doi:10.1016/j.legalmed.2008.03.005.
5. Yen K, Lövblad KO, Scheurer E, et al. Post-mortem forensic neuroimaging: correlation of MSCT and MRI findings with autopsy results. *Forensic Sci Int* 2007;**173**:21–35.
6. Thali M, Yen K, Vock P, et al. Image-guided virtual autopsy findings of gunshot victims performed with multi-slice computed tomography (MSCT) and magnetic resonance imaging (MRI) and subsequent correlation between radiology and autopsy findings. *Forensic Sci Int* 2003;**138**:8–16.
7. Jacobsen C, Schön CA, Kneubuehl B, Thali M, Aghayev E. Unusually extensive head trauma in a hydraulic elevator accident: post-mortem MSCT findings, autopsy results and scene reconstruction. *J Forensic Leg Med* 2008;**15**:462–6.
8. Brogdon BG. Definitions in forensics and radiology. In: Brogdon BG, editor. *Forensic radiology*. Boca Raton: CRC Press; 1998.. p. 3–11.
9. Brogdon BG. Forensic radiology in historical perspective. In: Brogdon BG, editor. *Forensic radiology*. Boca Raton: CRC Press; 1998.. p. 12–33.
10. Di Maio VJM. *Gunshot wounds: practical aspects of firearms, ballistics, and forensic techniques*. 2nd ed. Boca Raton: CRC Press; 1999.